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Addendum 1 to the CRI Technical Report, (Version: 2013, Update 1)

This addendum updates the Technical Report (Version:2013, Update 1) and details some revisions to our monthly parameter updates. More specifically, this addendum addresses two issues. First, it describes the revised sequential Monte Carlo (SMC) implementation for monthly calibrations of the CRI corporate default prediction model. Second, it explains the special corrective step implemented immediately prior to performing the August parameters update using the data up to July end. These revisions/corrections were prompted by the discovery of an irregular pattern in the term structure of forward intensity parameters pertaining to one covariate of India. The August calibration after revisions/corrections results in relatively minor differences in probabilities of default (PDs) as compared to those would otherwise have been if the revisions/corrections were not implemented. The changes described herein have been implemented and used for the probabilities of default (PDs) released on 21 August 2013.

The CRI PD prediction has been extended to the 5-year horizon since 1 April 2013 by adopting the Nelson-Siegel (NS) function to restrict parameters over different forward starting times. The SMC method of Duan and Fulop (2013) is essential to this CRI implementation (see Version 2012 Update 2 Addendum 7: Extension to 5 Year Forecast Horizon). A full SMC run up to January 2013 was first executed to obtain parameter estimates and then updated to February end in parallel to the CRI live system until the new system went live on 1 April 2013 with the calibrated parameters using data up to March end. The revisions/corrections primarily rest with the monthly updating algorithm. The irregularities in parameter estimation began to surface in the unreleased March 2013 calibration results, but continued to pass standard checks in place. They went on unnoticed until early August 2013, at which time the CRI team began to identify the causes and devise remedial solutions.

Modifications to the periodic updating algorithm

This section updates Technical Report (Version: 2013, Update 1) and describes the modifications to "Periodic updating" in Section 1.3.3 of the SMC method for parameter estimation subject to the NS function restriction. The technical description basically follows that of Duan and Fulop (2013: August 21, "Multiperiod Corporate Default Prediction with Partially-Conditioned Forward Intensity"). In an earlier version of their paper, the updating step is performed by factoring in the entire likelihood due to the new and revised data in one consolidated step. The new updating algorithm per their paper now divides the updating task into two sub-steps. Taking the August update (moving from June end to July end) as an example, the first sub-step revises the parameter particle cloud (parameter values and their

associated weights) to reflect revisions to the data up to June end. In addition to usual data revisions, the presence of July data makes one-month default predictions back in June possible. This aspect of generic data change was previously overlooked. The second sub-step is to advance from June end to July end using the revised June parameter particle cloud. Data tempering will be applied if the data due to one additional month suggests too big a move to be accomplished in one step.

Let θ be a set of NS parameters. With the arrival of one more month of data, the final date of the data set is increased from the previous month T to the current month $T + \Delta t$ where $\Delta t = 1/12$ (measured in years). Let the pseudo-posterior distribution at T (based on the old data set) be denoted by

$$\gamma_{T/\Delta t}^{(T)}(\theta) \propto \prod_{j=1}^{T/\Delta t-1} \mathcal{L}_{j,\min(T-j\Delta t,l)}^{(T)}(\theta)\pi(\theta),$$

and the pseudo-posterior distribution at $T + \Delta t$ (based on the new data set) be denoted by

$$\gamma_{T/\Delta t+1}^{(T)}(\theta) \propto \prod_{j=1}^{T/\Delta t} \mathcal{L}_{j,\min(T+\Delta t-j\Delta t,l)}^{(T+\Delta t)}(\theta)\pi(\theta),$$

where l is the prediction horizon ($l = 5$), $\pi(\cdot)$ is the prior, and $\mathcal{L}_{j,\tau}(\cdot)$ is the likelihood at prediction time $j\Delta t$ for the prediction interval $[j\Delta t, j\Delta t + \tau]$ with the superscript being introduced to differentiate the data set available at time T and $T+\Delta t$ respectively. It is important to note that $\mathcal{L}_{j,\tau}^{(T+\Delta t)}(\theta) \neq \mathcal{L}_{j,\tau}^{(T)}(\theta)$ can be caused by revisions to the old data set. More importantly, specifically due to multiperiod predictions, there is a generic difference between the pseudo-posterior distribution up to T under the new data set and the corresponding quantity under the old data set; that is, $\gamma_{T/\Delta t}^{(T+\Delta t)}(\theta) \neq \gamma_{T/\Delta t}^{(T)}(\theta)$ even without any data revisions to the period covered by the old data set. To put it concretely, using the new data set and at, say, one period before the last (i.e., time $T - \Delta t$), one can make default predictions up to two periods, whereas at the same time point, it was only possible to make one-period predictions under the old data set because there were no data beyond time T. Adjustments to the weights are thus necessary to reflect the change in data set before making any sequential updates.

From the previous run up to T, one already has a particle cloud $(\theta^{(i,T/\Delta t)}, w^{(i,T/\Delta t)})$ representing the pseudo-posterior distribution $\gamma_{T/\Delta t}^{(T)}(\theta)$.[1] Next, update the weights by

$$w^{*(i,T/\Delta t)} = w^{(i,T/\Delta t)} \times \frac{\gamma_{T/\Delta t}^{(T+\Delta t)}(\theta^{(i,T/\Delta t)})}{\gamma_{T/\Delta t}^{(T)}(\theta^{(i,T/\Delta t)})}.$$

[1]Note that the notations here differ slightly from Technical Report (Version: 2013, Update 1). The superscript of θ and w and subscript of γ in this addendum pertain to the natural time index whereas in the Technical Report, they refer to the default prediction time. This change will be reflected in the next update of Technical Report.

Since the denominator is available from the previous run, one only needs to compute the numerator using the new data set up to time T. Then, the weighted set of particles $(\theta^{(i,T/\Delta t)}, w^{*(i,T/\Delta t)})$ represents the revised pseudo-posterior distribution at time T, i.e., $\gamma_{T/\Delta t}^{(T+\Delta t)}(\theta)$, specifically due to the change of data set. From this point onward, one can apply the same recursive procedure described in Section 1.3.2, starting from equation (18), to complete the updating from time T to $T + \Delta t$.

Apart from the above changes, the CRI system has also removed the expansion factor applied to the standard deviations in generating block-independent normal distribution proposals for the additional 3 to 20 moves after completing the advancement step.

Special corrective step before the August update

The irregularities in parameter estimation manifest in rather poor coverage by some of the parameter particle clouds, a result accumulated from the monthly parameter update performed in March 2013 and onwards. Thus, the CRI team has devised a special corrective step and implemented it in this August calibration using data up to July end. The special correction is applied to June end to reset particle clouds. With the "correct" particle clouds, a normal monthly update is then performed per the description in the preceding section.

The special correction comprises four steps:

1) Read in the particle clouds obtained from the unreleased results for January end of 2013 (the initial SMC run before the first periodic update) and recalculate the likelihood up to January 2013 under the data set up to July end of 2013.
2) Perform a resampling step to avoid possible weight-concentrated particles.
3) Perform a move step with full acceptance. In particular, the standard deviations for the block-independent normal distributed proposals are those reflected by the updated particle clouds but floored by a minimum value of 1. This lower bound ensures that the particle cloud can move for cases that the computed standard deviation is minuscule.
4) Perform additional 100 move steps (without setting the standard deviation lower bound) to move the particle clouds to their rightful locations for data up to June end of 2013.

For the special correction, the move steps were also specialized for several economies as a way of ensuring that the term structure of forward intensity parameters are not stuck in their current implausible shapes. This additional control makes sure that newly sampled particles result in an increasing (or decreasing) structure of the NS function for the first five months, just like how some

forward intensity parameters are made to be negative (or positive) per the description in Technical Report.

However, the special correction cannot rectify the problems in the reported statistics because the use of self-normalized statistics requires a full SMC run to correct problems in earlier periods. The CRI team will conduct a full run as soon as it is operationally feasible.